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This is an application for Letters Patent of the United States of America on an invention

entitled

APPARATUS FOR IN-SITU REMEDIATION USING A CLOSED DELIVERY SYSTEM

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APPARATUS FOR IN-SITU REMEDIATION USING A CLOSED DELIVERY SYSTEM

The present application is related to provisional patent application serial number 60/437,981 entitled "Apparatus for In-Situ Remediation Using a Closed Delivery System" filed on January 6, 2003, priority from which is hereby claimed.

FIELD OF THE INVENTION

The present invention relates to apparatus for the sub-surface injection of remedial liquids, slurries and colloidal suspensions to treat impacted groundwater and soils.

BACKGROUND OF THE INVENTION

There are many methods and apparatus purposed for the treatment of contaminated matter. Burying the material, incineration, vacuum extraction, and microbial mineralization are just a few available options. Burying the waste is commonly how radioactive and recalcitrant materials are treated. Solids are deposited in shallow trenches about three meters wide and between three and five meters deep. When the waste is filled to about one meter from the top of the trench, the trench is covered with earth. A large volume of heterogeneous contamination is produced by such waste which may continuously seep into the soil and water. Incineration is another available option. The purpose of incineration is to burn off the contaminants and leave only the clean soil. However, this may be a very expensive process and not very feasible if large volumes of soil need to be treated. Also, it may have pollution side effects of vapor and air pollution while the soil is being removed and moved to the incineration site. Soil Vacuum Extraction (SVE) is a simple and economical treatment method, however organochloric compounds in a concentration of several ppm or lower may not be readily removed when entrained within clays or loams. Further channeling is frequently found within a SVE system,

1   further reducing the system's overall efficacy. Lastly, many compounds with poor Henry's

2   Constants will not be efficiently removed via an SVE approach. This physical approach

3   remediation process requires time in annual scale.

4   In order to solve the problems with the above-described methods, biological or in-situ

5   oxidation processes have been devised. Critical to any in-situ injection process is the efficient

6   delivery of materials to the targeted area or zone. Frequently materials may be injected by way

7   of a cylindrical delivery rod with an expendable point. This point is pushed out to allow for

8   pumped material to escape from the base of the injected point. In-situ remediation allows for

9   petroleum hydrocarbon, chlorinated solvents, metals and radonuculi to be treated without any

10   digging of the soil, so it can be performed where other treatment approaches may not be

11   practical.

12   In order to perform in-situ treatments, an apparatus for delivery is needed. The most

13   common and practical is a steel injection rod forced into the soil which causes preferential

14   pathways when materials are forced from its terminus, often along the interface between the rod

15   and the soil. These pathways prevent efficient application of remedial materials to the target

16   zone. To alleviate this problem, a hollow injection rod with lateral discharge holes allows for

17   liquids to be injected into the contaminated material and, when performed well, in-situ injections

18   are not only practical but also very economical. However, problems exist, for example

19   switching between feed systems cannot be accomplished without loss of pressure to the delivery

20   line. The resulting vacuum causes the delivery pathways to close and results in reduced lateral

21   distribution of delivered materials. It is because of these problems experienced from the vacuum

22   developed downhole as pressure is released and reapplied that many remedial technologies fail

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1   when transitioned from laboratory to field application. This is a problem that is further

2   exacerbated when it is desired to deliver dissimilar compounds sequentially for appropriate

3   remediation to occur.

4   ## SUMMARY OF THE INVENTION

5   The applicants have devised a closed, pressurized delivery system for in-situ delivery for

6   sub-soil remediation compounds to underground contaminated matter which includes first a

7   liquid diaphragm pump connected to an inflow source of water, the liquid diaphragm pump

8   being also in fluid communication with a plurality of bioslurry tanks connected in parallel, the

9   bioslurry tanks each having a drain. Valve means are located between the first liquid diaphragm

10   pump and each of the bioslurry tanks for controlling either the alternate or simultaneous flow of

11   fluid from the first pump to each of the bioslurry tanks. A second liquid diaphragm pump

12   having an inlet port for receiving the combined flow of the bioslurry tanks has an outlet in fluid

13   communication with a system discharge port. The system further includes a source of

14   compressed gas in fluid communication with the discharge port. A discharge rod is connected to

15   the discharge port for delivery of remedial fluids to underground soils. A gas pressure line leads

16   from a source of compressed gas to the discharge port and is also in fluid communication with a

17   plurality of feed tanks for storage of injectants under pressure, the feed tanks being individually

18   pressurized by the selective fluid communication with the pressure line. Each feed tank includes

19   a separately valved exhaust port connected to the system discharge port such that the source of

20   injectant may be switched from the bioslurry tanks to any of the feed tanks without loss of

21   delivery pressure. The source of pressurized gas may be a mechanical compressor or a stored

22   compressed gas.

1   The above-described closed delivery system utilizes a combination of gas and liquid

2   delivery systems in which all delivery vessels are interconnected and valved, allowing for

3   mixings, washings, filling, and discharge of materials via pressurized delivery vessels and

4   mechanical pumping systems. The system utilized allows for a variety of dissimilar compounds

5   to be delivered via a single injection line. Further, the switching between feed systems is

6   accomplished without any loss of pressure to the delivery line eliminating the common problems

7   experienced from the vacuum developed down-hole as pressure is released and reapplied. The

8   flexibility, and thus the field success of the system, is due to the unique configuration of gas and

9   liquid feed systems allowing for greater horizontal infiltration below grade and delivery to low

10   permeability soils such as compacted clays which is readily accomplished. Lastly, the current

11   system may be mounted in a mobile trailer, being fully self-contained and requiring no electrical

12   external supply. The only site utility requirement is an available water source for slurry

13   preparation. Other objects and advantages of the present invention will be readily apparent to

14   those of skill in the art from the following drawing and description of the preferred embodiment.

15   BRIEF DESCRIPTION OF THE DRAWINGS

16   Figure 1 is a diagram of the present invention.

17   DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

18   Referring now to Figure 1, a preferred apparatus is shown for carrying out the above-

19   described process. The direction of flow is indicated by arrows where appropriate. Not shown

20   are conventional injection rods well-known in the art suitable for subsoil injections which are

21   attached to an injection line in fluid communication with the discharge port 25.

22   The bioremediation apparatus of the invention comprises two feed tanks, T1 and T2; two

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1 bioslurry tanks, **LT1** and **LT2**; a liquid diaphragm pump, **P1**; and a second liquid diaphragm

2 pump, **P2**; a gas compressor; and an air storage tank. A liquid feed line from an outside water

3 source is attached to the liquid diaphragm pump, **P1**. The liquid feed lines are also connected to

4 the two bioslurry tanks, **LT1** and **LT2**. From the two bioslurry tanks, **LT1** and **LT2**, a liquid

5 feed line runs to the diaphragm pump, **P2**. The liquid feed line then runs to the two feed tanks,

6 **T1** and **T2**, and out the discharge port 25.

7 An inlet air line 21 is attached to the gas compressor. A gas pressure line is attached

8 from the gas compressor to the liquid diaphragm pump **P1** to the two feed tanks, **T1** and **T2**, and

9 out the discharge port 25. All of the lines are valved, allowing for mixings, washings, filling,

10 and discharge of materials. Valve **V1** is located within the gas line running from the gas

11 compressor toward the outlet. **V2** and **V3** are valves in the liquid line running to feed tanks **T1**

12 and **T2**. Valve **V4** is the liquid line controlling the flow from pump **P2**. Valves **V5** and **V6** are

13 located within the liquid feed line controlling flows from bioslurry tanks **LT1** and **LT2**. **V7** and

14 **V8** are liquid feed valves controlling flows into tanks **LT1** and **LT2**. **V9** is the discharge valve

15 controlling all flow going out of the trailer. **V10** and **V11** are gas feed valves controlling gas

16 flow into feed tanks **T1** and **T2**.

17 The system is attached to an injection rod which is a hollow, cylindrical pipe (not shown)

18 that has been drilled to a site of underground contamination with a flexible pressure hose. Under

19 high gas pressure, the injection rod is capable of injecting horizontal and vertical pathways

20 underground, both in deep and shallow depths. The steel injection rod has a steel tip used for

21 drilling. In order for the high pressure streams of liquid to be injected, the rod has a series of

22 ports drilled into the lower end of the rod. The injectants can therefore be injected in any

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1   direction.

2   A specific operation of the apparatus according to one embodiment of the invention may

3   be further described in conjunction with the following process. The process begins by first

4   filling the bioslurry tanks LT1 and LT2 and the feed tanks T1 and T2. A source of nitrogen is

5   connected to inlet 21 and a water supply is connected to liquid inlet 23. Valves V7 and V8 are

6   opened which engage an electric actuator to fill bioslurry tanks LT1 and LT2. A micro-

7   nutrients/sodium sulfate is then manually added to the bioslurry tanks LT1 and LT2 and allowed

8   to mix. Valves V7 and V8 are shut along with disengaging the actuator when the bioslurry tanks

9   are filled.

10   The injectant preparation phase continues as a pre-mixed heated lactate including

11   vitamins B2 and B12 is manually poured into feed tank T1. Valves V3, V4, V5, and V6 are then

12   opened. Next, pump P2 is activated and tank T2 is filled with an appropriate volume of the

13   bioslurry. All valves are closed when finished. Next, zero valent iron is manually added and

14   mixed with the bioslurry in tank T2. The tops are then secured on both feed tanks T1 and T2

15   and afterward valves V10 and V11 are opened to pressurize both feed tanks. After the injection

16   rod has been properly placed at a selected location, the injection line is secured to discharge port

17   25 and valve V9 is opened.

18   With the injectant preparation phase completed, the injection phase of the process begins.

19   Valve V1 is opened to create injection pathways until a significant pressure drop is observed at

20   the injection pressure vessel 31 which is filled with the source of compressed gas, preferably

21   either nitrogen or carbon dioxide. Valve V1 is then closed and valve V3 opened to introduce the

22   zero valent iron/bioslurry mixture into the subsurface pathways from feed tank T2. Valve V3 is

1   closed when feed tank **T2** is empty. Next, valve **V2** is opened to introduce the lactate mixture

2   into the subsurface from tank **T1** and is closed after it is empty. It will be understood by those of

3   skill in the art that switching between either the feed tanks or the bioslurry tanks occurs without

4   loss of pressure in the injection line therefore avoiding any down-hole vacuum that would

5   otherwise be experienced in switching from the delivery of one compound to another. This is an

6   important aspect of the invention.

7   Then, valves **V4**, **V5**, and **V6** are opened to directly deliver bioslurry from tanks **LT1** and

8   **LT2** into the subsurface. All valves are closed when the desired amount of bioslurry has been

9   injected. Finally, in order to cleanse the injection line of the viscous polylactate ester, a reducing

10   agent is once again injected. With the injections complete, a post injection line purge is

11   performed. The gas is injected to clear the lines of any remaining reducing agents. With the

12   lines cleaned, the process is complete and the next injection location is prepared.

13   It should be understood that there may be other modifications and changes to the present

14   invention that will be obvious to those of skill in the art from the foregoing description, however,

15   the present invention should be limited only by the following claims and their legal equivalents.